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Lane centering

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Tesla Autopilot in use

In road-transport terminology, **lane centering**, also known as **auto steer** or **autosteer**, is an advanced driver-assistance system that keeps a road vehicle centered in the lane, relieving the driver of the task of steering. Lane centering is similar to lane departure warning, but rather than warn the driver, or bouncing the car away from the lane edge, it keeps the car centered in the lane.[1][2][3][4] Together with adaptive cruise control (ACC), this feature may allow unassisted driving for some length of time.[5][6][7]

In addition to passenger vehicles, semi trucks are expected to be fitted with this technology, starting with the Tesla Semi and other vendors in 2019.[8][9]

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Terminology [edit source]

Lane departure warning generates a warning when the vehicle cross a line, while lane keeping assist helps the vehicle to avoid crossing a line, standardized in ISO 11270:2014,[10] and lane centering keeps the vehicle centered in the lane and almost always comes with steering assist to help the vehicle take gentle turns at highway speeds.[11]

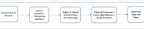
In farming, "machine autosteer" is a technology which make automated steering and positioning of a machine in a landscape.[12]

History [edit source]

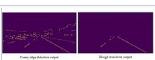
The first commercially available lane centering systems were based on off-the-shelf systems created by Mobileye, such as Tesla Autopilot and Nissan ProPilot,[13] although Tesla switched to an in-house design when Mobileye ended their partnership.[14] A handful of companies like Bosch, Delphi, and Mobileye provide sensors, control units, and even algorithms to car makers, who then integrate and refine those systems.[15]

While not directly attributable to lane centering, crash rates on the Tesla Model S and Model X equipped with the Mobileye system were reduced by almost 40% while Tesla Autopilot was in use.[16][17][18]

Operation [edit source]


Lane detection algorithm

The lane detection system used by the lane departure warning system uses image processing techniques to detect lane lines from real-time camera images fed from cameras mounted on the automobile. Examples of image processing techniques used include the Hough transform, Canny edge detector, Gabor filter and deep learning. A basic flowchart of how a lane detection algorithm works to produce lane departure warning is shown in the figures.



An example implementation of the lane detection algorithm showing Canny edge detection and Hough transform outputs

Limitations [edit source]

Features that differentiate systems are how well they perform on turns, speed limitations and whether the system resumes from a stop.[19][20]

Current lane centering systems rely on visible lane markings. They typically cannot decipher faded, missing, incorrect or overlapping lane markings. Markings covered in snow, or old lane markings left visible, can hinder the ability of the system.[21] GM's Super Cruise only works on known freeways that have been previously mapped,[22] as it uses a combination of these maps and a precise GNSS position provided by Trimble's RTX GNSS correction service to determine if Super Cruise can be enabled or not.[22]

Most vehicles require the driver's hands to remain on the wheel, but GM's Super Cruise monitors the driver's eyes to ensure human attention to the road,[23] and thus allows hands-free driving.

2018 Mobileye EyeQ4 [edit source]

Mobileye claimed in 2018 that 11 automakers would incorporate their EyeQ4 chip that enables L2+ and L3 autonomous systems; this would collectively represent more than 50% of the auto industry.[24] Level 2 automation is also known as "hands off": this system takes full control of the vehicle (accelerating, braking, and steering). Level 3 is also known as "eyes off": the driver can safely turn their attention away from driving, e.g. the driver can text or watch a movie.[25]

In 2018, the average selling price for the EyeQ4 chip to auto makers was about $450 U.S. dollars.[26]

Nissan uses the EyeQ4 chip for their hands-off ProPilot 2.0 system.[27]

Regulations [edit source]

In the United-States, in 2018, lane centering systems are not covered by any Federal Motor Vehicle Safety Standards, according to the NHTSA.[28]

Territories such as the European union, Japan, Russia, Turkey, Egypt and the United Kingdom follow UNECE 79 regulation.[29] In those territories following UNECE 79 regulation, automatically commanded steering functions are classified in several categories, for instance:

- Category A function helps the driver at speed no greater than 10 km/h for parking maneuvering;
- Category B1 function helps the driver to keep the vehicle within the chosen lane;
- Category B2 function "keeps the vehicle within its lane by influencing the lateral movement of the vehicle for extended periods without further driver command/confirmation";
- Category C and D and E are related to specific manoeuvres such as lane change[30]

While all those functions are related to automated steering, lane centering is a concept close to the concept related to category B2, while LKA is closer to category B1.

Sample of level 2 automated cars [edit source]

See also: Adaptive cruise control § Vehicle models supporting adaptive cruise control

Because all of these vehicles also have adaptive cruise control that can work in tandem with lane centering, they meet the SAE standard for level 2 automation. Adaptive cruise control and lane centering are often only available in more expensive trim levels rather than just the base trim. An example is the Hyundai Kona EV, which only has adaptive cruise control available on the "ultimate" edition.[31]

Sample of vehicles with lane centering ability

Manufacturer	Sample of vehicles	Branding for lane centering	Notes
Citroën	C4 and ë-C4	lane-keeping assist lane-centring assist[32]	
Daimler AG	Freightliner Cascadia big-rig[9][33][34][35] Actros[36]	Lane Keep Assist Active Drive Assist	
Fiat-Chrysler	Maserati brand[37]		
Ford	2021 F-150[38] Edge[39][40][41] Escape[42][43] Explorer[44] Focus[45][46][47] Mach-E[48]	Ford Co-Pilot360: Lane Centering	
GM	CT6,[49] 2021 Escalade	Super Cruise	Only on approved freeways[50] Uses eye tracking system, which does not require driver to hold steering wheel.
Honda	Insight[51] Odyssey[52][53] Pilot[54][55][56]	Honda Sensing: Lane keeping Assist System[57][58]	Between 45 mph and 90 mph[59]
	Acura MDX[60]	AcuraWatch	Only at higher speeds[61]
Hyundai	Palisade[62][63] Kona EV[64][65] Santa Fe[66][67][68] Elantra[69]	Lane Following Assist[70]	Also called Lane Keeping Assist, available at 60 km/h or above.[71]
Kia	Kia Niro EV[72][73] Kia Telluride[74][75][76] Stinger[77] K900[78] Forte[79]	Lane Following Assist[73]	Speed 0 - 130 km/h, 81 mph[73]
Lincoln	Aviator[80][81] Corsair Nautilus[82]	Lincoln Co-Pilot360: Lane Centering	
Mazda		Lane Trace	Can be activated at speeds above 60 km/h[83]
Mercedes	A-Class[84]	Driver Assistance Package	
Nissan	Leaf, Rogue[85][86] Altima[87][88][89]	ProPilot Assist	Under 31 mph, ProPilot lane centering will work when tracking another car in the lane.[90]
Subaru	Forester,[91] Outback,[92][93] Legacy[94][95]	Subaru Eyesight	Depth perception based on stereo cameras.[96][97] One of the few systems here, besides Tesla, not based on Mobileye tech.[98][99]
Tesla	Model S, X, 3, and Y[100]	Autopilot, Autosteer	Works at all speeds other than at certain margins above posted speed limits. V10 improvement notes.[101]
Toyota	Corolla[2][102] Rav4[103] Highlander[104] Lexus ES[105]	Lane Tracing Assist[106]	Part of second generation Toyota Safety Sense[107][108]
VW	2020 Atlas[109]	Traffic Jam Assist	Only works below 37 mph
	Audi A8[110]	2019 Traffic Jam Pilot[111]	Level 3 Autonomy. Germany first. Not for U.S.A. in 2019. Top speed: 37.3 mph, 60 km/h[112]
	Audi A6[113] Porsche Taycan[114]	Tour Assist[115]	Top speed 155 mph
Volvo	XC40[116] XC60[117][118] XC90[119]	Pilot Assist II[120]	

Nissan ProPilot [edit source]

ProPilot in use in a Nissan Leaf

Nissan ProPilot is based on Mobileye technology[121] and assists with acceleration, steering and braking input under single lane highway driving conditions.[122] ProPilot keeps the car centered in the lane and will deactivate below 31 mph if not tracking a car in front of it.[90] Adaptive cruise control handles stop-and-go traffic if stopped for less than 4 seconds[123] and helps maintain a set vehicle speed and maintain a safe distance between the vehicle ahead. ProPilot, which can follow curves,[124] uses a forward-facing camera, forward-facing radar and other sensors. A traffic sign recognition system provides drivers with the most recent speed limit information detected by a camera on the windshield, in front of the rear-view mirror.

In a review by ExtremeTech, ProPilot worked well in 1,000 miles of testing and only on some twisty sections did it require driver intervention.[125] During Euro NCAP 2018 testing, ProPilot failed some tests as did all other systems tested.[126][127] Consumer Reports indicates that ProPilot is especially helpful in stop and go traffic.[128]

Honda Sensing/AcuraWatch [edit source]

Honda Sensing and AcuraWatch are a suite of advanced driver assistance features including Lane Keeping Assist System (LKAS) which helps keep the vehicle centered in a lane, by applying mild steering torque if the vehicle is deviating from the center of a detected lane with no turn-signal activation by the driver.[129][130] Mild steering torque means the system will not work on tight turns; additionally, the system does not work at speeds below 45 mph. The Honda Sensing and AcuraWatch packages also include:

- Adaptive cruise control[129][130]
- Traffic-sign recognition
- Auto high beam

2018 evaluation by IIHS [edit source]

Quote from David Zuby, chief research officer at the American Insurance Institute for Highway Safety:[131]

> We're not ready to say yet which company has the safest implementation of Level 2 driver assistance, but it's important to note that none of these vehicles is capable of driving safely on its own...

The report indicated that only the Tesla Model 3 stayed within the lane on all 18 trials.

Quote from the report:

> The evidence for safety benefits of active lane-keeping systems isn't as pronounced as for ACC. Still, the potential to prevent crashes and save lives is large. IIHS research shows that preventing lane-departure crashes could save nearly 8,000 lives in a typical year...

See also [edit source]

- Advanced driver-assistance systems
- Autonomous car

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- Comma.ai open source lane centering system
- Real-world analysis of fatal run-out-of-lane crashes using the national motor vehicle crash causation survey to assess lane keeping technologies [1]

News [edit source]

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